Consumer Advisory for Commercial Fish

Maine Department of Human Services

Bureau of Health

Why Issue Advice on Commercial Fish?

- **It's the fish most commonly consumed**
  - ➢ **Women in focus groups asked for information**
  - ➢ **80% Maine women of childbearing age eat fish, BUT only 21% report eating any sport-caught fish**
  - ➢ **Higher hair mercury levels (e.g. > 1 ppm) associated with eating commercial fish**

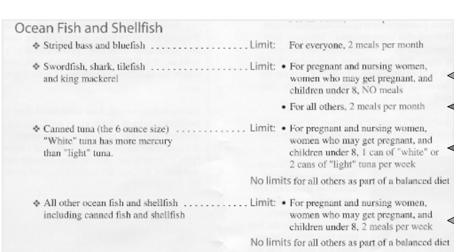
Consumer Advisory for Commercial Fish

Guiding Principles

- **Wanted to follow / support updated US FDA advice**
  - ➢ **BECAUSE – want to avoid confusion & strive for consistency**
  - ➢ **BECAUSE – want buy-in from health care providers**
- **Wanted to redirect fish consumption behavior toward fish lower in mercury**
  - ➢ **SO, single out "light" vs "white" canned tuna**
  - ➢ **SO, provide limits for general population**
- **Keep it simple**

Consumer Advisory for Commercial Fish

Consumer Advisory for Commercial Fish

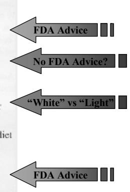


Ocean Fish and Shellfish

- ❖ Striped bass and bluefish .... Limit: For everyone, 2 meals per month
- ❖ Swordfish, shark, tilefish and king mackerel .... Limit:
  - • For pregnant and nursing women, women who may get pregnant, and children under 8, NO meals
  - • For all others, 2 meals per month
- ❖ Canned tuna (the 6 ounce size) "White" tuna has more mercury than "light" tuna. .... Limit:
  - • For pregnant and nursing women, women who may get pregnant, and children under 8, 1 can of "white" or 2 cans of "light" tuna per week

  No limits for all others as part of a balanced diet
- ❖ All other ocean fish and shellfish including canned fish and shellfish .... Limit:
  - • For pregnant and nursing women, women who may get pregnant, and children under 8, 2 meals per week

  No limits for all others as part of a balanced diet



Risk Communication Strategy

- **Target pregnant women**
  - ➢ **WIC clinics**
  - ➢ **OB/GYN, FP/OB, NMW**
- **Target fishing households with kids**
  - ➢ **Matches of Birth Certificate and Fishing License Registries**
- **Target newlyweds ?**
  - ➢ **Timed mailings based on marriage licenses**

Next Steps

- Improve risk communication materials
  - ➢ Redesign brochure for more general population
  - ➢ Mixing and Matching Limits
- Evaluate effectiveness
  - ➢ Surveys of random samples from birth certificate registry
    - ✓ awareness of “safe eating guidelines”
    - ✓ fish consumption behavior (changes?)
    - ✓ hair mercury levels

Acknowledgements

Funding Support

- U.S. Environmental Protection Agency
  Office of Water

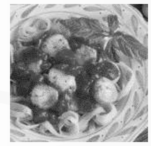
Collaborators

- Henry Anderson & Laurie Draheim, Wisconsin Division of Family and Community Health
- Sue Stableford, UNE Adult Health Literacy Center
- Doug Campbell, Campbell Creative

Methylmercury:
Ongoing Research on Toxicology

Kathryn R. Mahaffey, Ph.D.
U.S. Environmental Protection Agency, Washington, D.C.

Dietary Sources of Fish & Shellfish Vary Widely
Virtually All Contain Methylmercury




Current Toxicology Projects

- Brief note on NRC 2000 Methylmercury Assessment and US EPA's 2001 RfD
- ***Relation of biomonitoring measures.***
- Current reports on blood and hair mercury concentrations in the US
- ***Reports on adverse cardiac outcomes in adults***

Basis for US EPA's RfD for Methylmercury

"Methods and Rationale for Derivation of a Reference Dose for Methylmercury by the US EPA"

Deborah Rice, Rita Schoeny and Kathryn Mahaffey, *in press – Feb 2003*
Risk Analysis.

EPA's BMDL for Methylmercury Is Based On:

- Neuropsychological tests that indicate neuropsychological processes involved with a *child's ability to learn and process information.*
- ***Doubling*** the risk of scores in a range considered *clinically subnormal*.

Biomarkers of Mercury Exposure and the RfD

Relation of Cord/Fetal Blood Mercury Concentration and Maternal Blood Mercury Concentration

US EPA's Assessment of "Benchmark Dose Lower Bound" for Methylmercury

- BMDL based on a doubling of the prevalence of scores on tests of developmental function in a range recognized as clinically subnormal.
- Both US EPA and NRC utilized a BMDL of approximately 58 ug/L of ***cord*** blood.
- Dose conversion of ***cord*** blood [Hg] to ***maternal*** blood [Hg] assumed to be 1:1.

Comparison of Maternal Blood and Cord Blood Mercury Concentrations

Current risk assessments assume that cord blood and maternal blood [Hg] are equal.

More recent assessments indicate cord blood is, on average, 1.7 times higher in mercury than maternal blood concentrations.

58 ug/L cord blood [Hg] ~ 34 ug/L maternal blood [Hg]

Factors Contributing to Differences in Ratios

- Differences in kinetics of maternal distribution of methylmercury in her body.
- Differences in ratio of cord blood [CH3Hg] to maternal blood [CH3Hg]. Range of means from 2.17 to 1.08. Individual data far more variable. Vahter et al. (2000) reported 5^{th} and 95^{th} percentiles were 0.88 to 3.1.

Dose-Response on the Basis of Blood [Hg]

Cord [Hg] for BMDL: 58 ug/L

Maternal [Hg] at 1:1 cord:maternal ratio: 58 ug/L

Maternal [Hg] at 1.7:1 cord:maternal ratio: 34 ug/L

What range of maternal blood concentration are associated with a doubling of the prevalence of neuropsychological deficits?

Blood Mercury Concentrations in the United States Population

NHANES Data

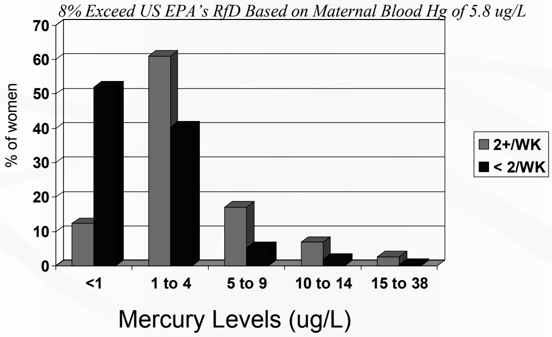
NHANES 1999/2000 - Blood Mercury

Women Ages 16 – 49 Years

Blood Hg Ug/L	***Number of Subjects***	***50^{th} Percentile***	***90^{th} Percentile***
Women	1709	0.94 (0.73 – 1.15)	4.84 (4.11 – 5.57)

Total Mercury Levels in Women,
Aged 16-49
by Weekly Fish Consumption Levels

8% Exceed US EPA's RfD Based on Maternal Blood Hg of 5.8 ug/L



US EPA's Reference Dose for Methylmercury

Effects in Adults

Are there cardiovascular effects of low-dose exposure to methylmercury?

Adult Cardiovascular Effects
Association with Mercury Exposures

- Salonen et al. studied 1983 men living in Eastern Finland aged 42 to 60 years (Salonen et al., Circulation 91:645-655, 1955; Atherosclerosis 148:265-263, 2000).
- Report that mercury is a risk factor for coronary and fatal cardiovascular disease.
- Dietary intake of fish and mercury were associated with significantly increased risk of acute myocardial infarction and death from coronary heart disease, cardiovascular disease and any death.
- Men in the highest tertile (2 ppm and higher) hair mercury had a 2-fold (95% CI 1.2 to 3.1; P=0.005) age- and CHD-adjusted risk of AMI and a 2.9-fold (95% CI, 1.2 to 6.6; P 0.014) adjust risk of cardiovascular death.
- Carotid intima-media thickness increased with increases in hair mercury concentration. Suggest mercury accumulation in the human body associated with accelerated progress of carotid atherosclerosis (Salonen et al., 2000).

Methylmercury: Exposure and Effects

Setting a Methylmercury Reference Dose (RfD) for Adults

Alan H. Stern, Dr.P.H., DABT

Division of Science, Research & Technology
New Jersey Department of Environmental Protection

Trenton NJ

The Two-Tiered Advisory Structure

- The policy of the U.S. EPA is to derive a single RfD per chemical
  - based on goal of protecting most sensitive group
  - generally, members of the sensitive group are not known, or cannot control their exposure (e.g., air, drinking water)
    - therefore, protection of sensitives results in overprotection of general population

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- However, for MeHg, the sensitive population is well characterized
  - women of childbearing age, pregnant women, young children
- Individuals have reasonable control over exposure
  - consumption of fish with lower Hg conc.

- In principle, this lends itself to a two-tiered advisory structure
  - sensitive population and general population
  - general population is not overly protected and has less potential limitations on obtaining nutritional value from fish
  - sensitive population is protected at more stringent level

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- Two-tiered approach based on two RfDs
  - neuro-developmental effects for sensitive population
    - current RfD
  - neurological effects for general population
    - paraesthesia – predictive and protective for progression of neurological effects
    - old RfD
      - from Iraq and Minimata

- Currently, 12-13 states follow such a two-tiered approach
- Appropriateness of approach is predicated on assumption:

  $Rfd_{gen} > RfD_{sens}$
- Current RfD = 0.1 ug/kg/day

  Old RfD = 0.3 ug/kg/day
  - difference is small, but significant for fish advisories

- Is assumption that $Rfd_{gen} > RfD_{sens}$ correct?

- NAS/NRC report highlights several areas of uncertainty for general ("adult") RfD
  - cardiovascular effects
  - immunotoxic effects

Summary of reported findings for cardiovascular endpoints for MeHg

- Salonen et al. (1995)
  - middle aged Finnish men
  - mean hair Hg = 1.92 ppm
    - approx. 2.3 times NJ general pop. mean
  - for hair Hg >2 ppm, adjusted RR for AMI, CHD, and CVD = 1.7-2.1
    - in NJ ~20% of general population >2 ppm

- Salonen et al. (2000)
  - middle aged men in Finland
  - 4 year follow-up assessing hair Hg, and atherosclerosis progression
    - ultrasound determination of carotid artery thickness
  - after adjustment for co-variates, men in upper quintile of hair Hg (2.8 ppm) had 40% increase in arterial wall thickness

Implications for Hg Fish Advisory Structure

- $RfD_{general} > RfD_{sensitive}$
  - retain two tiered advisory structure
    - currently only separated by 0.2 ug/kg/day
    - if $RfD_{general}$ decreases by 0.1 ug/kg/day will difference in advisories be significant?

- $RfD_{general} < RfD_{sensitive}$
  - one advisory?
    - does cardiovascular endpoint apply to women?

EPA Sponsored Effort

- Contract with State of NJ (in process)
  - PI - Dr. Alan H. Stern
  - Co-PI Dr. Andy E. Smith, ME

- State toxicologists, epidemiologists, risk assessors
  - 6-7 states represented

- independent consultants in statistics and cardio-epi

- 12-18 months duration

Occurrence of PBDE Flame Retardants in Fish

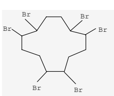
Robert C. Hale Virginia Institute of Marine Science
VIMS: M. La Guardia, E. Harvey, M. Mainor, E. Bush, M. Gaylor, S. Ciparis, M. Jacobs & D. Luellen
Virginia Dept. of Environmental Quality: J. Gregory, A. Barron, G. Darkwah & R. Browder

Brominated Flame Retardants (BFRs)

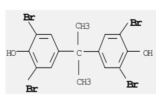
- Chemicals added (up to 30% by weight) to reduce fire hazard associated with our wide use of flammable polymers & textiles

BFR use saves:
- Lives
- Property
- Environmental damage

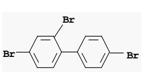
Brominated Flame Retardants (BFRs) Differ in Structure



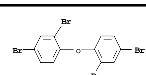
Hexabromocyclododecane (HBCD)



Tetrabromobisphenol-A (TBBP-A)

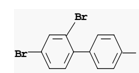


Polybrominated Biphenyls (PBBs)



Polybrominated diphenyl Ethers (PBDEs)

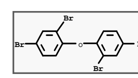
Once upon a time… we stopped using PBBs



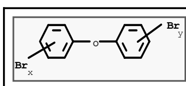
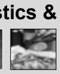
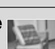
Learned that their structural similarity to PCBs and other persistent, *bioaccumulative & toxic* (PBT) chemicals was problematic

- PBBs accidentally introduced into MI livestock feed in 1973
- Destroyed large numbers of animals
- MI residents still carry PBB burdens.

Shhhh….Apparently we shifted to PBDEs instead…

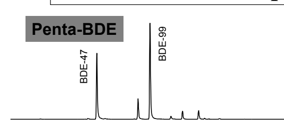


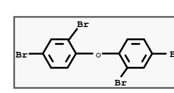
3 Commercial PBDE Mixes

	Uses Nondispersive?	1999 Demand American % of global use
Deca-BDE	Thermoplastics & textiles  	24,300 MT 44.3 %
Octa-BDE	ABS plastics 	1375 MT 35.9 %
Penta-BDE	Polyurethane foam 	8290 MT 97.5 %!!!

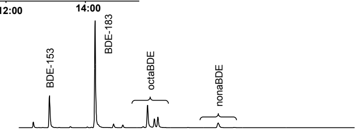
Commercial PBDE products

Penta-BDE

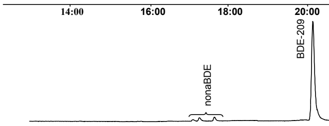




Octa-BDE

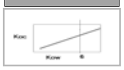


Deca-BDE

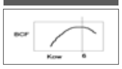


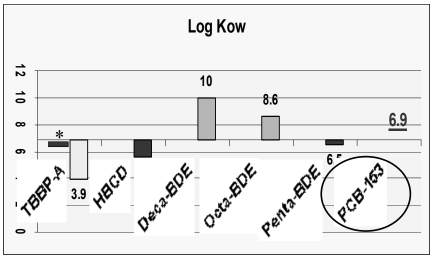
K_{ow} of BFRs versus PCB-153 Bioaccumulation & sediment partitioning

Sediments



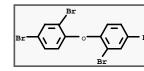
Biota





* Methylated TBBP-A log Kow 6.4

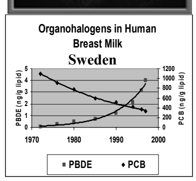
PBDEs: General Environmental Concerns



- Resistant to environmental degradation
- Long-range transport – POP?
  - Less brominated congeners – atm transport
- Accumulation in fish is a major pathway for human exposure – as per PCBs
- PBDEs accumulate in lipid-rich tissues
  - Penta-BDE mix > Octa-BDE > Deca- BDE
    - BDE-47 bioconcentration > PCBs

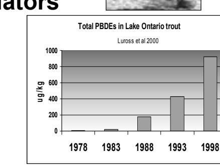
PBDE Research: Europeans More Active

- Reporting PBDEs in fish, mostly less brominated, since 1980's
- Detected even in remote areas
  - Arctic & deep ocean
- Rising in human breast milk
- E.U. Ban of Penta- mix in 2003
- Concern turning to Deca-BDE
  - Debromination?



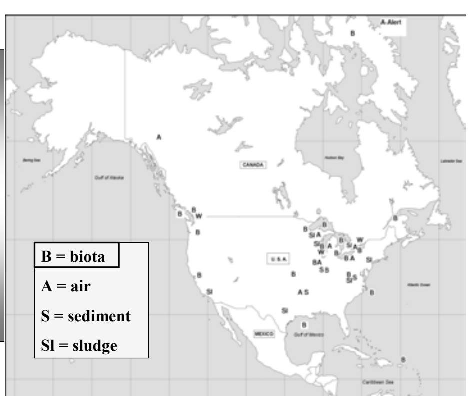
Overview: PBDEs in U.S.

- No specific U.S. regulations or widespread monitoring
- Detected in U.S. aquatic environment in 1987
  - EPA: Atlantic dolphin mortality event
    - Tetras – Hexa PBDEs ~ 200 ug/kg (lipid)
- Marine mammals high accumulators
  - Indigenous populations at future risk?
  - San Fran Harbor seal 8325 ug/kg
    - 65-fold increase from 1988-2000
- U.S. fish increasing over time
  - Penta-like congeners most common



Reports of PBDEs in North America limited- despite our high Penta- use

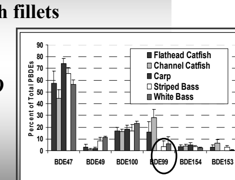
PBDE flame retardants in the North American Environment submitted to: *Environment International* 2002



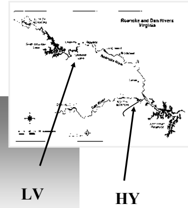
Case Study: PBDEs in Virginia Fish

In: Environ. Sci. Technol. 2001

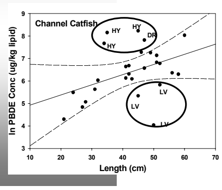
- VA DEQ/VIMS fish PCB study
- 1998-9 Roanoke Basin
- PBDEs ubiquitous in fish?
  - BDE-47 in 89% of Roanoke Basin fish fillets composited <u>fillets</u> (133 sites, n=332)
- 40-70% BDE-47; followed by –100 & -99
  - Carp anomalously low in BDE-99
  - Derived from Penta- mixture?
  - Deca- & Octa-BDEs absent



PBDEs in VA Fish

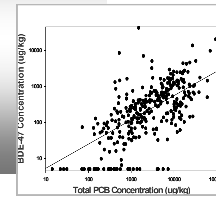


- In Roanoke/Dan River VA Basin
  - 16 “warm” spots (>1000 ug/kg lipid basis)
    - Highest in Hyco River
    - Lowest in Leesville Lake
      - surrounded by dams
  - Suggests <u>local</u> PBDE sources
    - *Debunks* “historical drilling muds” & “marine sponge” explanations



PBDEs in VA Fish

- Roanoke Basin fish among highest PBDEs in world
  - Home to numerous textile mills & furniture manufacturers
- Basin has historical PCB issues
  - PCBs/PBDEs in fish often correlated
    - …but not always
    - …different uses of PCBs & PBDEs
- BDE-47 conc. rivaled PCB-153 in half of fish samples

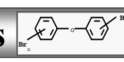


PBDEs in VA Fish



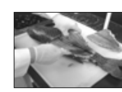
- One VA “hot” spot
  - “Innocuous” Hyco River skirts VA/NC border
    - Small tributary of the Dan River
  - Exceeded Viskan River fish (Sweden)
  - Carp fillet 47,900 ug/kg (lipid), PCBs low
    - Equivalent to 1000-2000 ug/kg wet
    - VDH set fish advisory limit of 5000 ug/kg
    - Source remains under investigation
      - Sewage treatment plant related?

PBDE Take-Home Concepts



- BFRs serve a crucial role
- 3 PBDE mixes have different uses, properties & risks
- Penta-BDE product most bioaccumulative in fish
- U.S. uses 98% of global Penta-BDE production
- PBDEs are now ubiquitous & environmental levels increasing
- Point & nonpoint sources of PBDEs exist, magnitudes uncertain
- Congener pattern in fish differs from commercial mixtures
  - Impacts risk calculation
  - Complicates source & fate determination



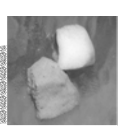


PUF as a Source of BDEs to Sludge?

BDEs in foam?

10% of 1 kg=100g

Exposure to UV & weather



Foam yellows, surface fragments

Foam fragments carried to STP

Sorption & inclusion in solids

STP Sludge 100,000 kg @ 1000 μg/kg!

PBDEs: Toxicology and Human Exposure

Linda S. Birnbaum, Ph.D., D.A.B.T.
NHEERL/ORD/US EPA

Major Industrial Products
(~67 metric tons/year)

- DBDE – largest volume (75% in EU)
  - 97% DBDE; 3% NBDE
  - Polymers, electronic equipment>textiles
- OBDE
  - 6%HxBDE; 42%HpBDE; 36% OBDE; 13%NBDE; 2%DBDE – multiple congeners (unclear if any PeBDE)
  - Polymers, esp. office equipment
- PeBDE
  - Textiles – esp. polyurethane foams (up to 30%)
  - Recommended ban in EU(no production/only import)
  - Mainly PeBDE+TeBDE, some HxBDE

PBDEs in Biotic and Abiotic Samples

- Air: 47>99>100>153=154
- Sediment: 99>47 (pattern reflects commercial PeBDE); also some nona and deca
- Sewage Sludge: 1-3mg/kg in US; pattern ~PUFs
  - Point sources (~DBDE) --->0.1-5 mg/kg
- Biota: 47>99=100 except if near manufacturing site (pattern does NOT reflect commercial PBDEs)
- Invertebrates≤Fish<<marine mammals

PBDEs (con) Ecotoxicity

- PeBDE>>OBDE>DBDE
  - Highly toxic to invertebrates (Larval development, LOECs in low µg/l range)
- DBDE/OBDE
  - May be low risk to surface water organism and top predators
  - Concern for waste water, sediment, and soil organisms
  - CONCERNS:
    - Presence of lower brominated congeners in OBDE
    - Photolytic and/or anaerobic debromination
    - Formation of PBDDs/PBDFs

Mammalian Toxicity of PBDEs

- Hepatotoxic
- Enzyme Induction
- DBDE – hepatocarcinogen (high dose)

Neurotoxic Effects

- Developmental Neurotoxicants
  - Perinatal; neonatal – pnd10 in mice
  - 47,99,153,209
  - Spontaneous behavior (mice)/hyperactivity
  - Permanent changes in brain function
- Developmental exposure -→Increased susceptibility of adults exposed to low doses of PBDEs
- *In vitro* changes in signalling pathways

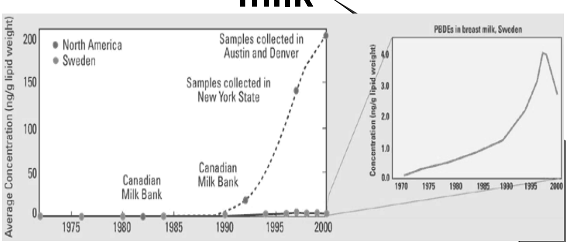
Endocrine Disrupting Effects

- AhR Effects
  - Relevance for commercial BFRs?
    - combustion can produce PBDDs/PBDFs
    - Recently found in human adipose tissue
- Thyroid
  - OH-PBDE metabolites bind to transthyretin
  - Parent PBDEs - Effects on T4 seen *in vivo*
    - induction of UDP-glucuronyl transferase
    - Rats and mice; body burdens as low as 0.8 mg/kg
- Estrogenic
  - OH-PBDEs
  - Sulfotransferase inhibition (mostly *in vitro)*

Pharmacokinetics of PBDEs

- Absorption – DBDE is poorly absorbed
- Distribution – lipid binding is important
  - Fat: 47>99>>>209
  - Liver: covalent binding from 99,209
- Metabolism – hydroxylation, debromination, O-methylation
- Excretion – feces is major route

Trends of BDEs in human milk



Betts : Env Sci Technol Dec, 2001

Total BDEs in contemporary human milks (ng/kg lipid) (Ryan and Patry, 2002)

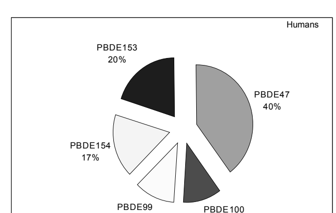
Country	No samples	Year	Median	Mean
Sweden	93	1996-1999	3.2	4.0
Japan	12	2000 ?	1.4	1.3
Canada	50	2001-02	25	64
USA (adipose)	23	1998	41	86

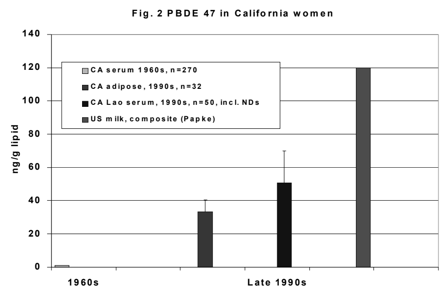
Total BDEs (n=7) in Canadian individual human milks (ng/kg lipid) (Ryan and Patry, 2002)

Location	No samples	Year	Median	Mean
Canada	72	1992	3.0	15
Canada	50	2002	25	64

PBDEs in Human Samples

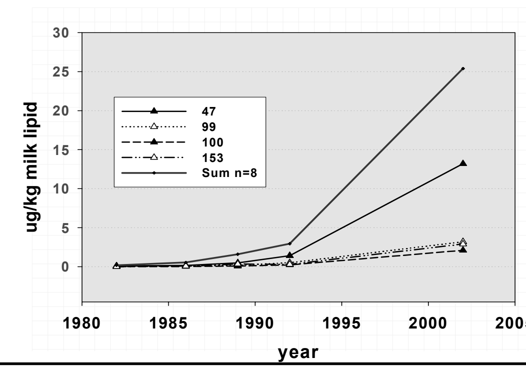
(Petreas et al., 2002)

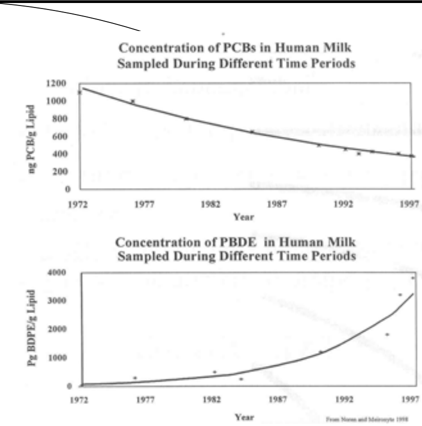




(Petreas et al. 2002)

Time Trends of BDEs in Canadian Breast Milk (Ryan and Patry, 2002)





Ryan and Patry, 2002

PBDEs in Human Samples

- Pattern of congeners is different from commercial mixtures (and food)
  - 47>99 in US and Europe(others: 100,153,183, 209?)
  - In Japanese, 99 and 153>47
- Large interindividual differences
- Increasing time trends – levels doubling every 2-5 years
- PBDEs and PCBs levels are not correlated
  - In most samples today, PCBs>PBDEs
- different sources and/or time sequence

Time Trends of Biotic Levels

- Rapid increases from 70s thru 90s
- Maybe slight decrease in Sweden
  - Ban on use of PeBDE?
- Levels still increasing in America
  - Continued use of PeBDE?
- ARE LEVELS HIGH ENOUGH TO SEE EFFECTS??? NEED MORE TOX DATA!

What next?

- More systematic human and environmental monitoring
- More information on fate and transport – are commercial products breaking down? And into what?
- More tox data - Focus on congeners present in people and wildlife, NOT commercial products since they are altered in the environment

Polybrominated Diphenyl Ethers (BDEs)

Khizar Wasti, Ph.D.

Virginia Department of Health

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http://www.vdh.state.va.us/hhcontrol

Toxicity of Deca-BDE

- The acute toxicity in experimental animals is low; oral LD50 in rats is >5mg/kg.
- No adverse effects were noted in rats fed at doses of up to 800 mg/kg BW for 30 days
- No evidence of carcinogenic, reproductive, teratogenic, or mutagenic effects
- Epidemiological studies in occupationally exposed workers did not indicate any symptoms attributable to BDEs exposure
- Oral RfD 0.01 mg/kg/day

Toxicity of Octa-BDE

- Low acute oral toxicity; LD50 in rats >5-28 g/kg
- Low chronic toxicity
- Teratogenicity-at doses of 25 and 50 mg/kg BW, resorptions or delayed ossification of different bones and fetal malformations were noted in rats. These changes were not seen at 15 mg/kg or less. In rabbits there was no teratogenicity, but fetotoxicity was seen at maternally toxic dose of 15 mg/kg. A no-effect level was 2.5 mg/kg
- Mutagenicity- negative
- Carcinogenicity- no data available
- IRIS Data Base- Oral RfD 0.003 mg/kg/day

Toxicity of Penta-BDE

- Low acute oral toxicity; LD50 in rats 6-7 g/kg
- Rats given diet containing 100 mg/kg for 90 days showed no clinical effects
- Not found to be mutagenic
- No data on carcinogenicity
- IRIS Data Base- Oral RfD 0.002 mg/kg/day

Toxicity of Tetra-BDE

- Virtually no human or animal data are available
- Toxicity may be similar to commercial Penta-BDE since it contains significant amount of tetra-isomer

Derivation of Allowable BDE Levels in Fish

Based on oral RfD,

Penta-isomer	0.002 mg/kg/day
Octa- isomer	0.003 mg/kg/day
Deca-isomer	0.01 mg/kg/day

BDE Task Force

- Virginia Department of Health
- Virginia Department of Environmental Quality
- Virginia Department of Game and Inland Fisheries
- Virginia Institute of Marine Sciences
- North Carolina Department of Health and Human Services
- North Carolina Department of the Environment
- U.S. Environmental Protection Agency
- Centers for Disease Control and Prevention

Selection of RfD for Risk Assessment

- Use the RfD value for penta-isomer, 0.002 mg/kg/day
- EPA suggested an interim RfD for tetra-isomer, 0.001 mg/kg/day. This RfD was based on the assumption that the tetra-BDE was twice as toxic as the penta-isomer

Derivation of Acceptable Concentration in Fish

$$C = \frac{RfD \times BW \times T}{MS \times NM}$$

C = acceptable concentration
RfD= reference dose
BW = average adult weight (70 kg)
T = Time period, 30 days/month
MS = meal size, 8-ounce or 0.227 kg
NM = number of meals/month, 2

Allowable Concentration of BDEs in Fish for Two Meals per Month

$$\frac{0.001 \text{ mg/kg/day} \times 70 \text{ kg} \times 30 \text{ days/month}}{0.227 \text{ kg/meal} \times 2 \text{ meals/month}}$$

= 4.62 ~ 5.0 mg/kg or parts per million (ppm)

Number of Allowable Fish Meals per Month at Various BDE levels

Concentration		# of Meals per month
1	ppm	9.3
1.47	ppm	6.3
2	ppm	4.6
3	ppm	3.1
4	ppm	2.3
5	ppm	1.9
9	ppm	1
10	ppm	0.9

Guidance for Issuing Fish Consumption Advisories

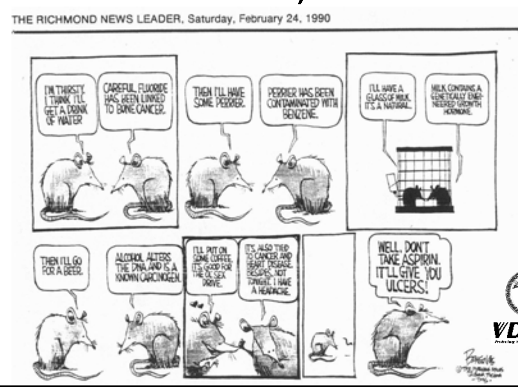
BDE concentrations

- Below 5 ppm — No Advisory
- 5 ppm - < 10 ppm — Two 8-oz meals/month
- >10 ppm — No consumption

Since reproductive or developmental effects of tetra-BDE have not yet been evaluated, it would be prudent for pregnant women, nursing mothers, and young children to avoid consumption of fish contaminated with BDEs above 5 ppm

The Dose Makes the Poison

Not every contaminant (in low concentrations) is harmful



EMERGING SCIENCE OF THE DIOXIN REASSESSMENT

Dwain Winters
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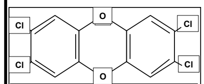
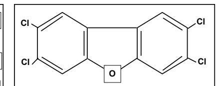
Office of Pollution Prevention and Toxics
US EPA
202 566 1977
winters.dwain@epa.gov

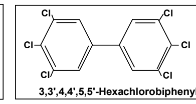
Dioxin-Like Compounds



2,3,7,8-Tetrachlorodibenzo-p-dioxin



2,3,7,8-Tetrachlorodibenzofuran



3,3',4,4',5,5'-Hexachlorobiphenyl

Dioxins
75 congeners
7 toxic

2,3,7,8-TCDD
1,2,3,7,8-PeCDD
1,2,3,4,7,8-HxCDD
1,2,3,6,7,8-HxCDD
1,2,3,7,8,9-HxCDD
1,2,3,4,6,7,8-HpCDD
1,2,3,4,6,7,8,9-OCDD

Furans
135 congeners
10 toxic

2,3,7,8-TCDF
1,2,3,7,8-PeCDF
2,3,4,7,8-PeCDF
1,2,3,4,7,8-HxCDF
1,2,3,6,7,8-HxCDF
1,2,3,7,8,9-HxCDF
2,3,4,6,7,8-HxCDF
1,2,3,4,6,7,8-HpCDF
1,2,3,4,7,8,9-HpCDF
1,2,3,4,6,7,8,9-OCDF

PCBs
209 congeners
12 toxic

3,3',4,4'-TeCB
3,3',4,4',5-PeCB
3,3',4,4',5,5'-HxCB
Plus 9 others

Toxic Equivalency (TEQ)

- *Fundamental to evaluation of this group of compounds*
- *Based on inspection of multiple endpoints and/or receptor binding (WHO criteria)*
- *Reassessment Chapter Summarizes Scientific Support*
- *WHO_{98} internationally accepted*

Five Compounds Make up About 80% of the Total TEQ in Human Tissue

- Four of 17 Toxic CDD/CDF Congeners
- One of the 12 toxic PCBs
  - *2,3,7,8-TCDD*
  - *1,2,3,7,8-PCDD*
  - *1,2,3,6,7,8-HxCDD*
  - *2,3,4,7,8-PCDF*
  - *PCB 126*

Current Dioxin Exposure/Body Burdens

- ~ 1 PG TEQ/Kg/Day (PCDDs/PCDFs/PCBs)
- Possible Higher Intake Populations
  - Nursing infants
  - Fatty Diet
  - Some subsistence fishermen and farmers in proximity to contamination

Body Burden Best Dose Metric

(Ng/Kg BW)

- *Accounts for differences in half-life*
- *Results in strong agreement between human and animal data*
- *Adopted by WHO, EC, HHS*

Dioxins and Human Carcinogenicity

2,3,7,8-TCDD	➔	Carcinogenic to humans
Other dioxin-like compounds	➔	Likely to be carcinogenic
Complex Environmental Mixtures	➔	Likely to be carcinogenic

Based on:
- Unequivocal animal carcinogen
- Limited human information (epidemiological/other)
- Mechanistic plausibility

Cancer potency increasingly focusing on human studies

Note: (IARC) classified TCDD as a Category 1, "Known" human carcinogen. DHHS 9th Report on Carcinogens (ROC) the same

Quantitative estimate of cancer risk

- **Cancer slope factor is based primarily on recently published analyses of human studies and is revised upward by a factor of ~6 over the 1985 EPA value based on 1978 study in rats**
- **Cancer risks to the general population may exceed 10^{-3} (1 in 1,000) from background (dietary) exposure but are likely to be less and may even be zero for some individuals**

Non-cancer Toxicants in Animals and Humans

- ➔ Developmental Toxicity
  Targets:
  - Developing Immune System
  - Developing Nervous System
  - Developing Reproductive System
- ➔ Immunotoxicity
- ➔ Endocrine Effects
- ➔ Chloracne
- ➔ Others

Body Burdens Associated With Non-Cancer Effects

➔ **Adverse Effects**	**Ng/Kg**	**MOE***
Developmental neurotoxicity:	22	*4*
Developmental/reproductive toxicity:	0.7 - 42	*0.1 - 8*
Developmental immunotoxicity:	50	*10*
Adult immunotoxicity:	1.6 - 12	*0.3 - 2*
Endometriosis:	22	*4*
➔ **Biochemical Effects**		
CYP1A1 Induction:	0.6 - 33	*0.1 - 7*
CYP1A2 Induction:	2.1 - 83	*0.4 - 17*

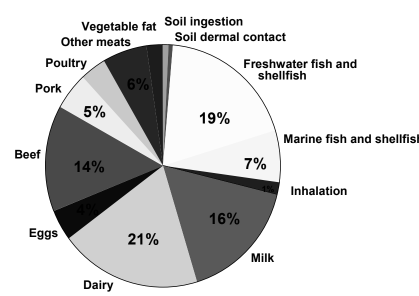
***MOE = effect level / current average U.S. background body burdens of 5 Ng/Kg**

Characterization of Non-Cancer Effects

- **Identification of non-cancer effects in animals and human are sufficient to generate a similar level of concern to cancer**
- **Adverse non-cancer effects have been observed in animal and humans within 10 times background exposure.**
- **It is likely that part of the general population is at, or near, exposure levels where adverse effects can be anticipated**
- **EPA will rely on MOE rather than RfD as the risk descriptor for dioxin non-cancer risk**

U.S. Adult Average Daily Intake of CDDs/CDFs/ Dioxin - Like PCBs

65 pg TEQ_{DFP}-WHO_{98}/day



U.S. Levels in Food CDD/CDF/PCB

TEQ_{WHO98} (whole weight basis)

Media	CDD/CDFs[a]	References	PCBs[a]	References	Total
Beef ppt	n=63 **0.18** ± 0.11 Range = 0.11 - 0.95	Winters et al. (1996a)	n = 63 **0.084**	Winters et al. (1996b)	**0.26**
Pork, ppt	n=78 **0.28** ± 0.28 Range = 0.15 - 1.8	Lorber et al. (1997b)	n = 78 **0.012**	Lorber et al. (1997b)	**0.29**
Poultry, ppt	n=78 **0.068** ± 0.070 Range = 0.03 - 0.43	Ferrario et al. (1997)	n = 78 **0.026**	Ferrario et al. (1997)	**0.094**
Milk, ppt	n=8 composites **0.018**	Lorber et al. (1998b)	n = 8 composites **0.0088**	Lorber et al. (1998b)	**0.027**
Dairy, ppt	n = 8 composites 0.12	Based on data from Lorber et al. (1998b)	n = 8 composites **0.058**	Based on data from Lorber et al. (1998b)	**0.18**
Eggs, ppt	n=15 composites **0.081**[e]	Hayward and Bolger (2000)	n = 18 plus 6 composites **0.10**[d,e]	Schecter et al. (1997) Mes and Weber (1989), Mes et al.	**0.13**
Vegetable Fats, ppt	n=30 **0.056** ± 0.24[g]	Versar (1996b)	n = 5 composites **0.037**[e]	Mes et al. (1991)	**0.09**
Freshwater Fish and Shellfish, ppt	n=222 **1.0**[d]	Fiedler et al. (1997), Jensen and Bolger (2000), Jensen et al. (2000), U.S. EPA (1992)	n = 1 composite of 10 samples plus 6 composites **1.2**[de]	Schecter et al. (1997) Mes and Weber (1989), Mes et al. (1991)	**2.2**
Marine Fish and Shellfish,	n=158 **0.26**[d]	Fiedler et al. (1997a), Jensen et al. (2000)	n = 1 composite of 13 **0.25**[d,e]	Schecter et al. (1997), Mes et al. (1991)	**0.57**

Background CDD/CDF TEQs in Fish and Shellfish, Consumption Rates, and Intakes

Fish Class	Species	Consumption Rate (g/day)	N	CDD/CDF TEQ Conc. (Pg/g fresh wt.)	CDD/CDF TEQ Intake (pg/day)
Estuarine Finf	Flounder (e)(f)	0.58	3	1.8	1.0
	Rockfish/Striped Bass (d)	0.043	26	1.2	0.052
	Salmon (d)	0.042	39	0.57	0.024
	Mullet (a)	0.034	2	0.068	0.0023
	Other				
	Flatfish	0.39	0		
	Perch	0.19	0		
	Croaker	0.13	0		
	Herring	0.12	0		
	Anchovy	0.042	0		
	Smelts	0.0074	0		
	Eel	0.0038	0		
	Sturgeon	0.00017	0		
	Total Other*	0.88	0	1.3	1.1
Freshwater Finfish	Catfish-farmed (b,d,h)	0.90	30	2.0	1.8
	Trout-farmed (e,h)	0.41	6	1.9	0.78
	Perch (e) (walleye)	0.17	3	1.2	0.20
	Carp (e)	0.14	4	1.2	0.17
	Pike (e) (pickerel)	0.035	3	0.49	0.017
	Salmon (d)	0.00083	39	0.57	0.00047
	Other				
	Whitefish	0.012			
	Cisco	0.0012	0		
	Smelts,	0.00050	0		
	Rainbow	0.00017	0		
	Sturgeon	0.014	0		
	Total Other*		0	1.3	0.018
Total Freshwater/Est. Finfish		**3.3**	**116**	**1.6**	**5.3**
Freshwater/Estuarine Shellfish	Shrimp (b,c)	2.0	19	0.080	0.16
	Crab Average (i)	0.30	33	0.37	0.11
	Oyster Average (i)	0.15	18	0.47	0.070
	Scallop (d)	0.0011	11	0.16	0.00018
	Crayfish (i)	0.0090	25	0.30	0.0027
	Other				
	Clam	0.014	0		
	Snails	0.0017	0		
	Total Other**	0.0157	0	0.43	0.0068
Total Freshwater/Est. Shellfish		**2.5**	**106**	**0.14**	**0.35**
Unknown Freshwater/Est. Species	Fish***	0.14	0	1.3	0.18
Total Fresh./Est. Fish		**5.9**	**222**	**1.0**	**5.8**

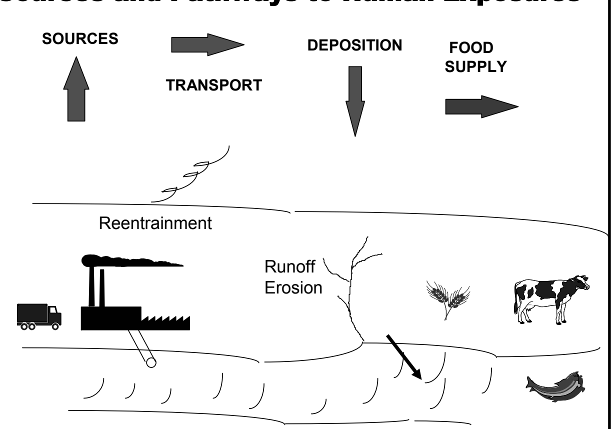
Background CDD/CDF TEQs in Fish and Shellfish, Consumption Rates, and Intakes

Fish Class	Species	Consumption Rate (g/day)	N	CDD/CDF TEQ Conc. (Pg/g fresh wt.)	CDD/CDF TEQ Intake (pg/day)
Marine Finfish	Tuna (c)	3.1	16	0.060	0.19
	Cod (c)	1.4	18	0.15	0.21
	Salmon (d)	1.3	39	0.57	0.74
	Pollack (d)	0.25	19	0.22	0.055
	Mackerel (a)	0.11	1	0.95	0.10
	Other				
	Porgy	0.36	0		
	Haddock	0.31	0		
	Whiting	0.26	0		
	Squid	0.17	0		
	Perch	0.13	0		
	Sardine	0.12	0		
	Sea Bass	0.10	0		
	Swordfish	0.098	0		
	Pompano	0.084	0		
	Octopus	0.073	0		
	Flatfish	0.045	0		
	Halibut	0.035	0		
	Snapper	0.032	0		
	Whitefish	0.012	0		
	Smelt	0.0066	0		
	Shark	0.0046	0		
	Roe	0.0011	0		
	Total Other****	1.8	0	0.39	0.72
Total Marine Finfish		**8.0**	**93**	**0.25**	**2.0**
Marine Shellfish	Scallop (d)	0.19	11	0.16	0.030
	Lobster (d)	0.19	16	0.26	0.049
	Crab (d)	0.16	38	0.36	0.058
	Other				
	Clams	0.70	0		
	Mussels	0.070	0		
	Conch	0.0021	0		
	Snails	0.0017	0		
	Total Other****	0.77	0	0.26	0.20
Total Marine Shellfish		**1.3**	**65**	**0.26**	**0.34**
Unknown Marine Species	Seafood (g)***	0.080	0	0.39	0.031
	Fish***	0.220	0	0.39	0.09
Total Marine Fish		**9.6**	**158**	**0.26**	**2.5**
TOTAL FISH		**15.5**	**292**(j)	**0.53**	**8.3**

Pathways and Sources of Human Exposures

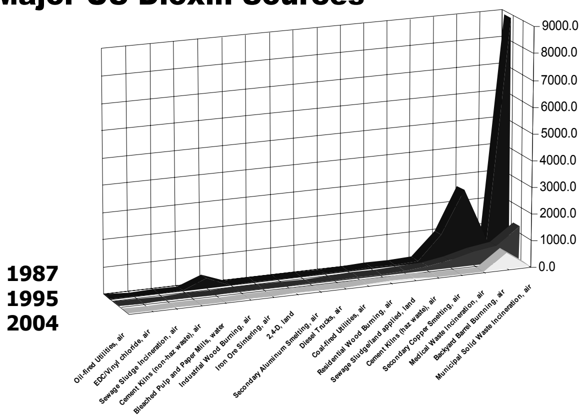
- **Pathways:**
  - ➔ **Ingestion of soil, meats, dairy products, fish**
  - ➔ **Inhalation of vapors and particulates**
  - ➔ **Dermal contact with soil**
- **Sources:**
  - ➔ **Combustion**
  - ➔ **Metal Smelting, Refining, Processing**
  - ➔ **Chemical manufacturing**
  - ➔ **Biological and Photochemical Processes**
  - ➔ **Reservoir sources**

Sources and Pathways to Human Exposures

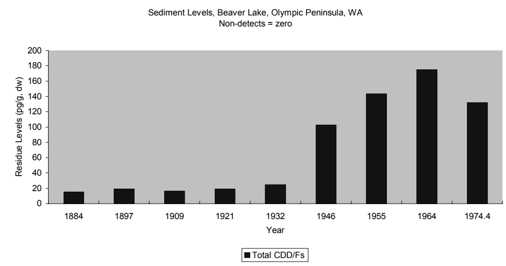


Inventory of Sources of Dioxin in the United States- Sept, 2000 draft	1987 Emissions (g TEQdf-WHO98/yr)	1995 Emissions (g TEQdf-WHO98/yr)	*% Total 1995*
Municipal Solid Waste Incineration, air	8877.0	1250.0	38%
Backyard Barrel Burning, air	604.0	628.0	19%
Medical Waste Incineration, air	2590.0	488.0	15%
Secondary Copper Smelting, air	983.0	271.0	8%
Cement Kilns (haz waste), air	117.8	156.1	5%
Sewage Sludge/land applied, land	76.6	76.6	2%
Residential Wood Burning, air	89.6	62.8	2%
Coal-fired Utilities, air	50.8	60.1	2%
Diesel Trucks, air	27.8	35.5	1%
Secondary Aluminum Smelting, air	16.3	29.1	1%
2,4-D, land	33.4	28.9	1%
Iron Ore Sintering, air	32.7	28.0	1%
Industrial Wood Burning, air	26.4	27.6	1%
Bleached Pulp and Paper Mills, water	356.0	19.5	1%
Cement Kilns (non-haz waste), air	13.7	17.8	1%
Sewage Sludge Incineration, air	6.1	14.8	0%
EDC/Vinyl chloride, air	NA	11.2	0%
Oil-fired Utilities, air	17.8	10.7	0%
Crematoria, air	5.5	9.1	0%
Unleaded Gasoline, air	3.6	5.9	0%
Hazardous Waste Incineration, air	5.0	5.8	0%
Lightweight ag kilns, haz waste,air	2.4	3.3	0%
Kraft Black Liquor Boilers, air	2.0	2.3	0%
Petrol Refine Catalyst Reg., air	2.2	2.2	0%
Leaded Gasoline, air	37.5	2.0	0%
Secondary Lead Smelting, air	1.2	1.7	0%
Paper Mill Sludge, land	14.1	1.4	0%
Cigarette Smoke, air	1.0	0.8	0%
EDC/Vinyl chloride, land	NA	0.7	0%
Primary Copper, air	0.5	0.5	0%
EDC/Vinyl chloride, water	NA	0.4	0%
Boilers/industrial furnaces	0.8	0.4	0%
Tire Combustion, air	0.1	0.1	0%
Drum Reclamation, air	0.1	0.1	0%
TOTALS	13,995	3,252	
Percent Reduction from 1987		77%	
updated 3/08/01			

Major US Dioxin Sources



20th Century Trend



Poorly Characterized Sources

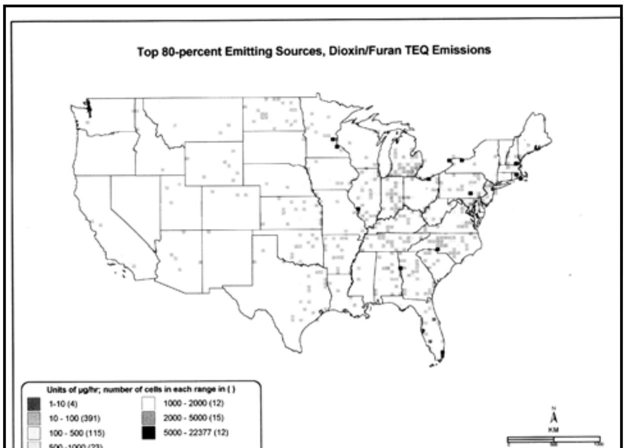
- Secondary steel electric arc furnaces
- Coke production
- Ceramic manufacturing
- Clay processing
- Ferrous and non-ferrous foundries
- Asphalt mixing plants
- Primary magnesium
- TiO_2
- Wood stoves
- Forest fires
- Brush fires
- Range fires
- Ag burning
- Landfill fires
- Structural fires
- Landfill flares
- Rural soil erosion to water
- Urban runoff to surface water
- Utility poles and storage yards
- Landfill fugitive emissions
- Transformer storage yards

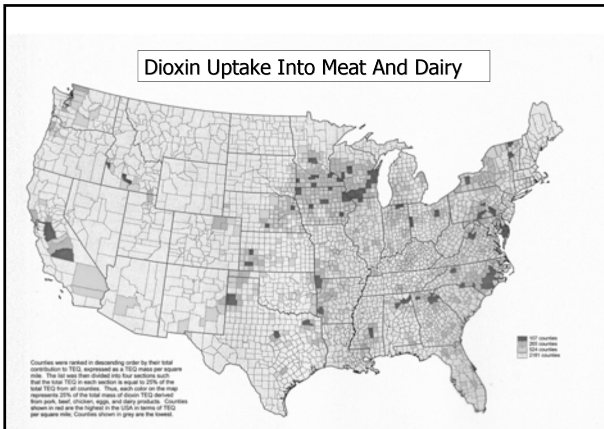
Reservoir Sources

Old releases of dioxins that are temporarily stored in environmental compartments to later be reintroduced into the circulating environment:

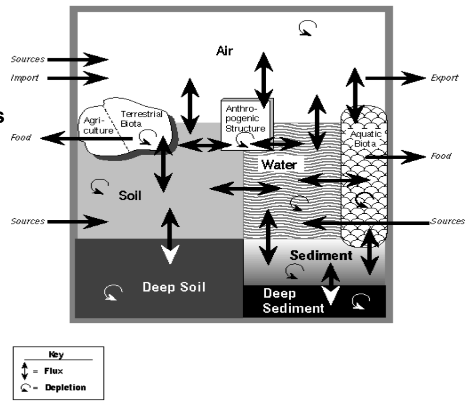
- Soil
- Sediment
- Biota
- Materials

Reservoirs contribute as much as 50% to general population exposure.



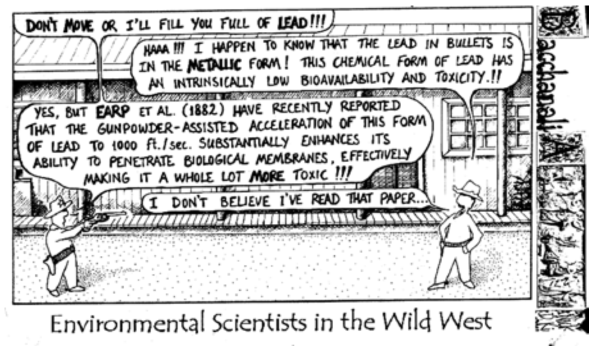


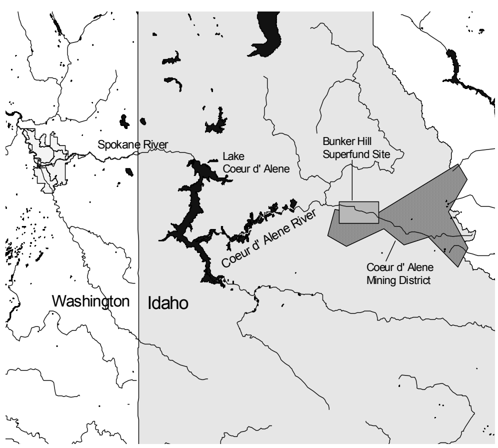
Fluxes Among Dioxin Reservoirs



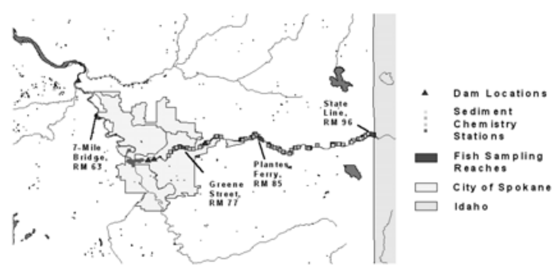
Application of the Lead IEUBK Model to Assess Spokane River Fish Consumption Health Risks

Lon Kissinger, U.S. EPA Region 10

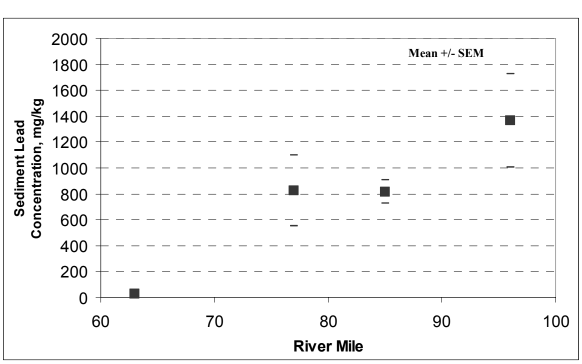




Fish Tissue & Sediment Sampling Locations



Spokane River Sediment Lead Concentrations Near Fish Sampling Locations



Lead Risk Assessment

- Based on internal measure of exposure, **blood lead level (PbB)**
- Risks assessed by comparing predicted population PbB values to PbB values associated with health effects.
- This approach integrates lead risks for all exposure routes.

Dose-Response → ?Threshold

Sub-clinical

Observed Effect	Children Blood Lead µg/dl	Adults Blood Lead µg/dl
Death	≥125	?
Neurological		
Encephalopathy	70	100
Peripheral Neuropathy	40	40
Central Nervous System		
↓ Hearing		10
↓ Cognitive IQ	10	-
↓ Psychomotor Function	10	-
↓ Birth weight/ Term length	10	-
Anemia	20	80
↓ Heme synthesis	10	10
Renal nephropathy	40	40
Hypertension		25
↓ Vitamin D	< 30	
↓ Sperm count & function		40

Adapted from Casserett & Doull's TOXICOLOGY and ATSDR

Models Used to Assess Lead Health Risks

- Models used:
  - Risks to children: ages 0 to 84 months assessed using the Integrated Exposure Uptake Biokinetic Model (IEUBK)
  - Risks to developing fetus: determined using the adult lead model.
- Information at: **EPA's Lead Technical Review Workgroup: http://www.epa.gov/superfund/programs/lead/**

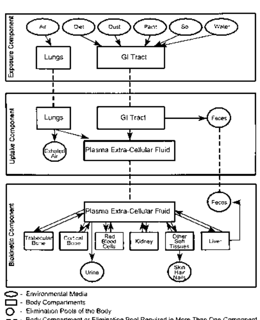
EPA IEUBK Model for Lead

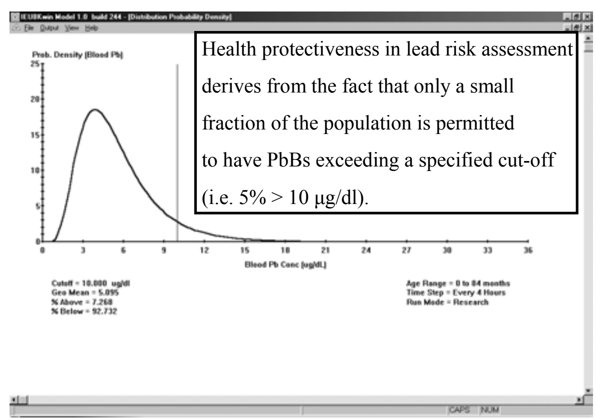
Integrated Exposure Uptake BioKinetic

Exposure

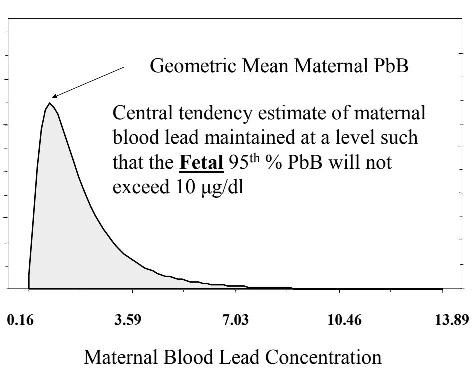
Uptake

BioKinetics

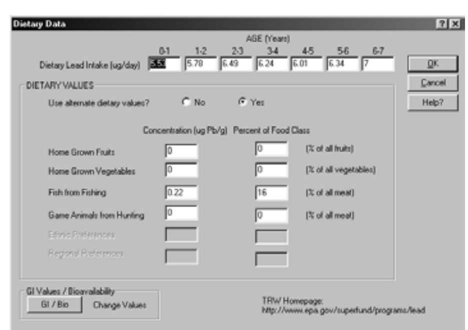




The Adult Lead Model



Dietary Lead Input Screen for the IEUBK Model



Key IEUBK Model Parameters

- Fraction of meat consumption that consists of locally caught fish.
- Concentration of lead in fish tissue.
- Lead concentration and intake rates for other media (e.g. water, soil, house dust)

Fraction of Meat Consisting of Spokane River Fish: Fish Consumption Rate

- What childen's fish consumption rate to use?
- Identified populations included:
  - Recreational anglers
  - Laotians
  - Russian immigrants that consumed fish cakes prepared by grinding fish after removal of head & spine.
- **Problem**: No quantitative information

Fraction of Meat Consisting of Locally Caught Fish: Fish Consumption Rate (continued)

- Opted to use tribal fish consumption rates for children age 0 to 72 months.
- Rates taken from the Columbia River Intertribal Fish Commission Fish Consumption Study (EPA, 2002).
- 65th percentile consumption rate of 16.2 g/day was used as a health protective central tendency estimate.

Fraction of Meat Consisting of Locally Caught Fish: Meat Consumption

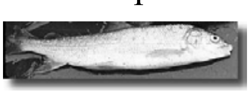
IEUBK model variable: meat_all(t)

Meat Consumed per Day by Age Group

Age (months)	g/day
12-24	87
25-36	96
37-48	102
49-60	107
61-72	112
72-84	121

Avg. for children 0-72 months = 101 g/day, therefore, a fish consumption rate of 16.2 g/day is 16% of total meat consumption

Fish Species Assayed for Lead

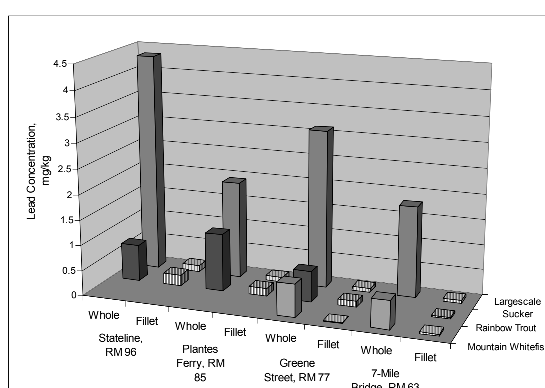


Mountain Whitefish

Largescale Sucker

Rainbow Trout

Spokane River Fish Fillet & Whole Body Lead Concentrations

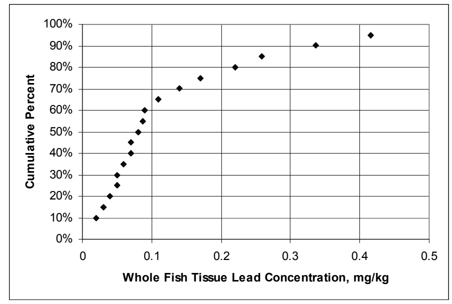


Comparison of Spokane River Average Whole Fish Lead Levels with National Values (mg/kg)

	Schmitt			Spokane River	
Statistic	Overall	Rainbow Trout	Largescale Sucker	Rainbow Trout	Largescale Sucker
Mean	0.168	0.15	0.115	0.823	2.79
SD	0.393		0.09		
N	315	2	17		

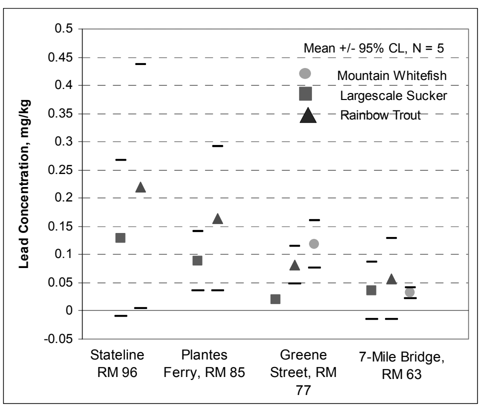
C.J. Schmitt and W.G. Brumbaugh, 1990. National Contaminant Biomonitoring Program: Concentrations of Arsenic, Cadmium, Copper, Lead, Mercury, Selenium, and Zinc in U.S. Freshwater Fish, 1976-1984. Archives of Environmental Contamination and Toxicology. 19:731-747.

Distribution of Lead Concentrations in Whole Fish



C.J. Schmitt and W.G. Brumbaugh, 1990

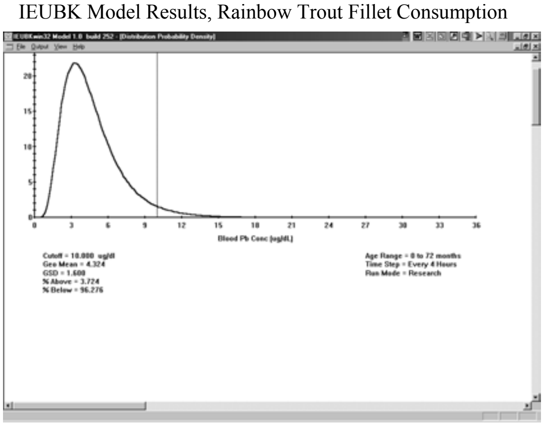
Spokane River Fish Fillet Lead Concentrations



Selected IEUBK Model Parameters

- Stateline trout fillet lead concentration of 0.22 mg/kg.
- Soil concentration of 230 mg/kg.
- All other parameters set at model defaults.

IEUBK Model Results, Rainbow Trout Fillet Consumption



PbBs Resulting from Consumption of Whole Fish

Species	Max Observed Concentration (mg/kg)	% > 10 Micrograms per dl
Largescale Sucker	**4.34**	**62%**
Rainbow Trout	**1.14**	**15%**
Mountain Whitefish	**0.56**	**6%**

Computing Pb Fish Fillet Consumption Limits

In order to run the IEUBK model, fish meals are converted to fish intake as % of meat intake:

$$\frac{(\text{N meals per month X 8 oz.}) / 30 \text{ days X } 28.349 \text{ g / oz.}}{\text{IEUBK daily meat intake in g / day}}$$

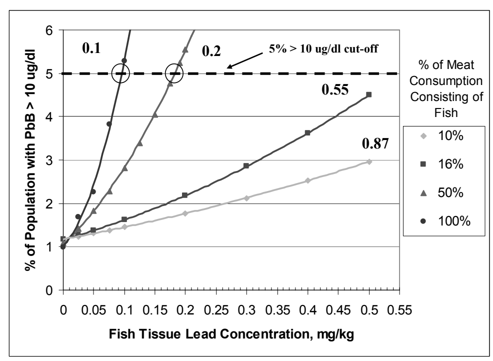
Comparison of Children's and Adult Fillet Meal Limits

	8 oz. Meals per Month	
	IEUBK	**ALM**
Species	**Children**	**Adults**
Rainbow Trout	**4**	**8**
Largescale Sucker	**7**	**14**
Mountain Whitefish	**13**	**52**

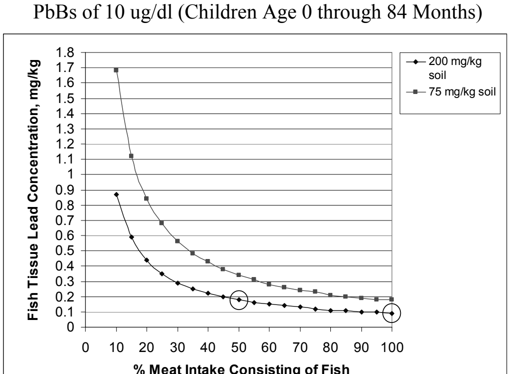
PCB Based Spokane River Fish Consumption Limits

	PCB Conc., ppb		Allowable 8 oz. Meals per Year	
Species	**Avg.**	**High End**	**Avg.**	**High End**
Rainbow Trout	**880**	**1312**	**2.6**	**1.7**
Largescale Sucker	**148**	**182**	**15.2**	**12.4**

PbB by Fish/Meat Diet Fraction & Fish Lead Concentration



Combinations of % Fish/Meat Intakes & Fish Tissue Lead Concentrations That Cause 5% of the Population to have PbBs of 10 ug/dl (Children Age 0 through 84 Months)



Issues/Model Improvements to consider:

- Consider altering the model to accept more population specific dietary information.
- Evaluate how the model does with subsistence consumption.
- Are there differences in bioavailability of lead found in bone/cartilage vs. muscle tissue?
- Change consumption rate data entry from fish as % of meat consumption to g/day.

Acknowledgements

- **Nancy Beck**, U.S. OMB
- **Steven Box**, USGS
- **Robert Duff**, WA Dept. of Health/ATSDR
- **Art Johnson**, WA Dept. of Ecology
- **Mike LaScuola**, Spokane Regional Health District
- **Terry Maret**, USGS
- **John Roland**, WA Dept. of Ecology
- **Marc Stifelman**, U.S. EPA

Equations for the Adult Lead Model

Intake of Lead from Soil and Fish

$$\mathbf{PbB_{adult,\ central} = PbB_{adult,0} +}$$

$$\mathbf{BKSF \times (PbS \times IR_s \times AF_s \times EF_s + PbF \times IR_F \times AF_F \times EF_F) / AT}$$

Equations for the Adult Lead Model (continued)

What maternal blood lead level will be protective of the fetus?

$$PbB_{fetal,\ 0.95\ goal} = PbB_{adult,\ central\ goal} \times GSD^{1.645} \times R_{fetal/maternal}$$

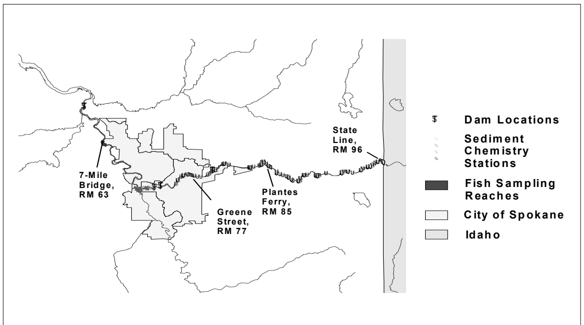
$$PbB_{adult,\ central\ goal} = (PbB_{fetal,\ 0.95\ goal}) / (GSD^{1.645} \times R_{fetal/maternal})$$

Finally, is $PbB_{adult,\ central} < PbB_{adult,\ central\ goal}$?

Supplement

- The following slides were not presented at the forum but were provided by the author for inclusion in the proceedings.

Spokane River Sediment and Fish Sampling Locations

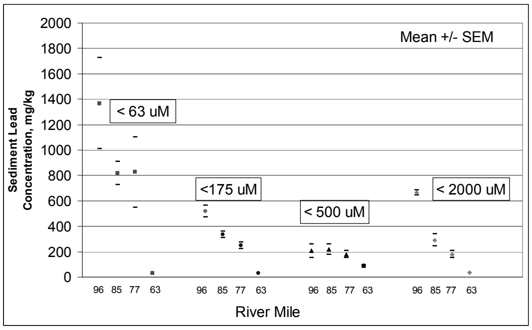


Relationship Between Particle Size and Sediment/Tissue Lead Concentration

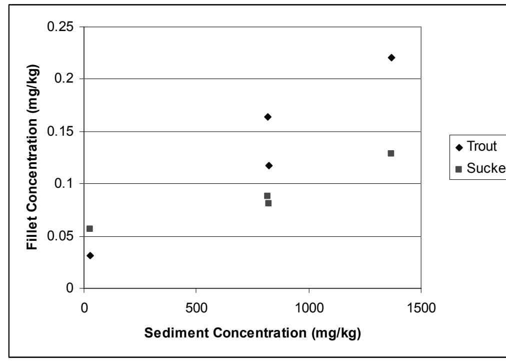
- Lead analyses done for particle size ranges of <63 µM, <175 µM, <500 µM & <2000 µM
- Avg. lead concentrations for each size range determined for sediment stations in the vicinity of fish sampling areas.
- Fillet/Whole fish vs. sediment lead concentrations plotted for different size ranges.

Sediment data compiled by Box and Wallis, USGS, 2000

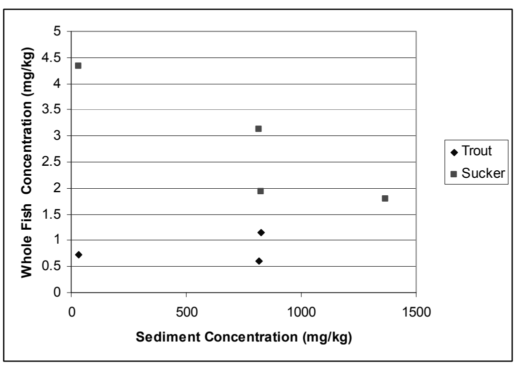
Sediment Lead Concentrations by Reach and Particle Size



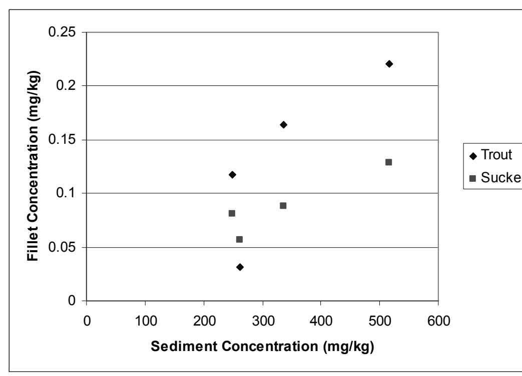
Sediment - Fillet Lead Concentration Relationship, Particle Size <63 µM



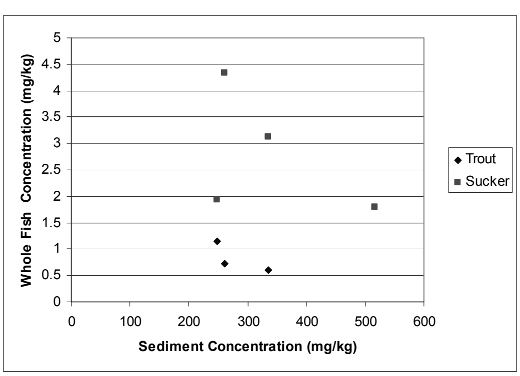
Sediment – Whole Fish Lead Concentration Relationship, Particle Size <63 µM



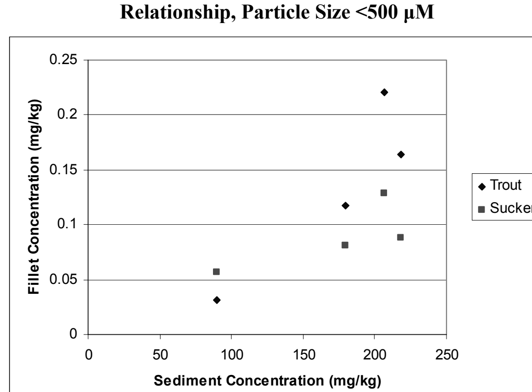
Sediment - Fillet Lead Concentration Relationship, Particle Size <175 µM



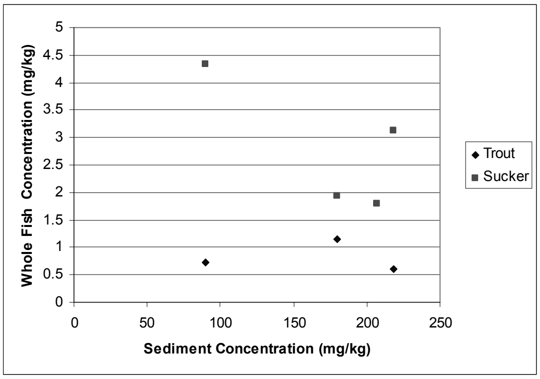
Sediment – Whole Fish Lead Concentration Relationship, Particle Size <175 µM



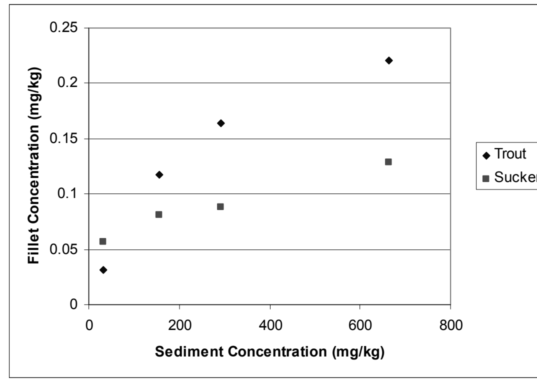
Sediment - Fillet Lead Concentration Relationship, Particle Size <500 µM



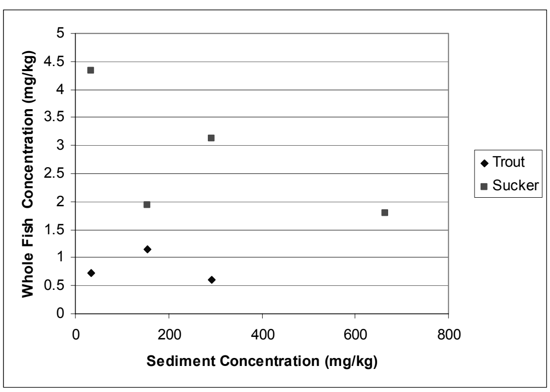
Sediment – Whole Fish Lead Concentration Relationship, Particle Size <500 µM



Sediment - Fillet Lead Concentration Relationship, Particle Size <2000 µM



Sediment – Whole Fish Lead Concentration Relationship, Particle Size < 2000 µM



Ratio of Fillet Tissue to Sediment Lead Concentration

Particle Size	Rainbow Trout	Large Scale Sucker
<63	3.9E-04	5.5E-04
<175	3.8E-04	2.6E-04
<500	7.1E-04	5.3E-04
<2000	6.5E-04	6.8E-04
All Sizes	5.3E-04	5.1E-04

Comments on Use of Lead Tissue/Sediment Ratios

- Lead tissue/sediment ratios may be a useful method for screening as to whether or not fish consumption lead hazards exist.
- More work needs to be done to characterize these ratios.

Occurrence of Lead in Fish

Examples from Georgia,
Maine, and California

A Note on Contamination
during Sample Preparation

Georgia

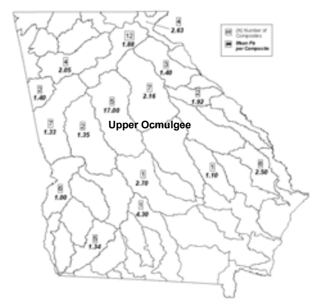
Summary of Detected Lead
Concentrations in Fish Fillet
Composites

Georgia
Means of Detected Lead Values Only
by Basin

	All Species		Largemouth Bass		Channel Catfish	
Basin	Composites (N)	Mean Lead (ppm)	Composites (N)	Mean Lead (ppm)	Composites (N)	Mean Lead (ppm)
Altamaha	1	1.10	1	1.10		
Chattahoochee	25	1.52	4	1.98		
Coosa	4	2.05				
Flint	7	1.34	3	1.33	3	1.30
Ocmulgee	6	14.62	3	8.57	2	15.50
Oconee	7	2.16	2	2.55		
Ogeechee	6	2.50	1	2.50	1	2.50
Savannah	9	2.06	3	2.28		
Suwannee	1	4.30				
Tallapoosa	2	1.40				

Other detects in hogsuckers, trout and sunfish

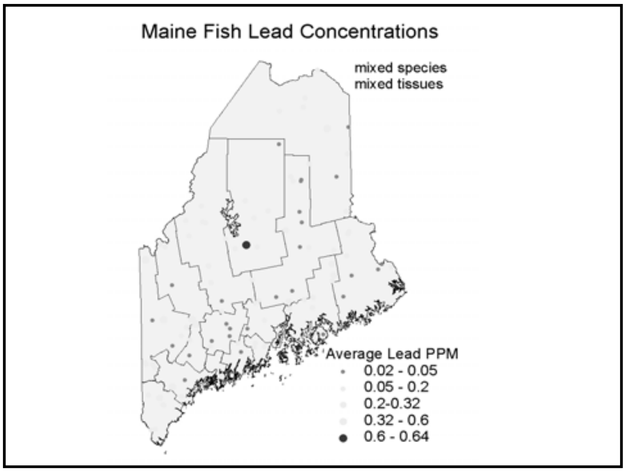
Georgia
All Species (Pb)

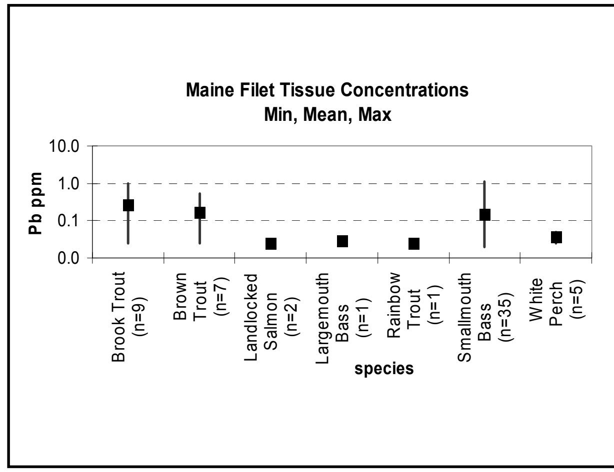


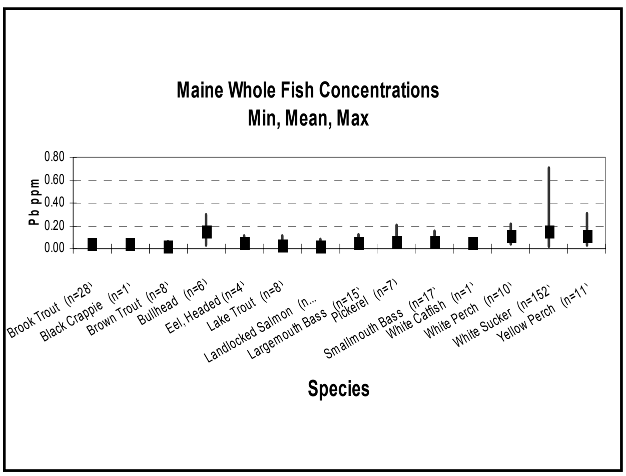
By Hydrologic Unit

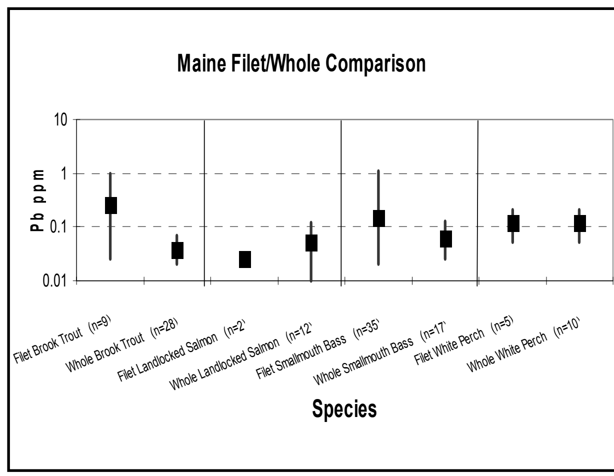
Georgia
Largemouth Bass (Pb)

Georgia
Channel Catfish (Pb)





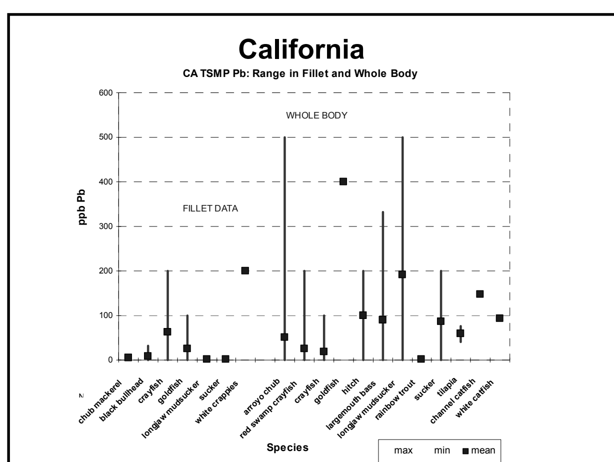




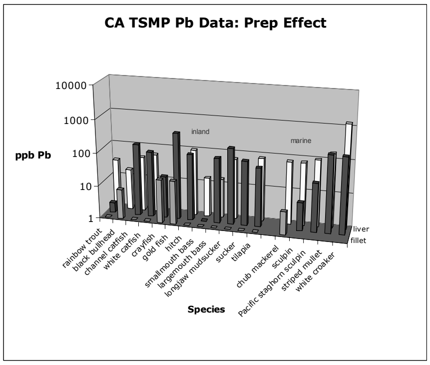
California

Fillet Non-detects in TSMP

Species	N	Species	N
Arroyo chub	1	Lahonton cutthroat trout	1
Bluegill	4	Largemouth bass	7
Brook trout	1	Mozambique tilapia	1
Brown trout	4	Orangemouth corvine	1
Carp	4	Rainbow trout	1
Channel catfish	4	Red swamp crayfish	5
Green sunfish	1	Brown smoothhound shark	1
Hitch	1	Leopard shark	1



California



The Effects of Sample Preparation on Measured Concentrations of Eight Elements in Edible Tissues of Fish from Streams Contaminated by Lead Mining

Christopher Schmitt and Susan E. Finger

Arch. Environ. Contam. Toxicol. 16, 185-207 (1987)

Effect of Preparation Method

Grand (seven sites) geometric mean concentration lead In ppm

Taxa	Normal Prep	Clean Prep	Difference
Bass N=13	0.097	0.024	4X
Catfish N=13	0.314	0.031	10X
Redhorse N=14	0.228	0.220	equal

Redhorse sucker has intermuscular bones

Conclusions

- **Preparation methods can effect reported Pb concentration**
- **Cross contamination from skin, bone, mucus and scales can effect reported Pb concentration**
- **Cross contamination and non-muscle fragments can effect sample heterogeniety**

Acknowledgements

Eric Frohmberg, Maine

Randy Manning, Georgia